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(54) HIGH-Cr MARTENSITIC STAINLESS STEEL PIPE FOR LINEPIPE HAVING EXCELLENT CORROSION RESISTANCE AND WELDABILITY, AND ITS PRODUCTION METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a high-Cr martensitic stainless steel pipe for a linepipe having excellent corrosion resistance and weldability, and to provide its production method.

SOLUTION: A steel pipe having a composition containing ≤0.02% C, ≤0.07% N, 0.2 to 7.0% Ni, 0.2 to 3.0% Mo and 10 to 14% Cr, and in which the contents of Si, Mn, P and S are controlled to proper ranges is heated to a temperature equal to or higher than the Ac3 transformation point, is then cooled at a cooling rate equal to or higher than that of air cooling to form a quenched structure, and thereafter, the steel pipe is tempered at ≥520°C to precipitate a γ-phase and to form a martensitic structure containing the γ-phase of ≥5% by area ratio. Further, one or more kinds selected from ≤0.15% Ti, ≤0.2% Nb, ≤0.15% Zr, ≤0.2% V and ≤0.15% Ta and ≤0.006% Ca may be incorporated therein.

[Claim 1]A high Cr martensitic stainless steel pipe for line pipes excellent in corrosion resistance and weldability having an organization characterized by comprising the following.
By mass %, C:0.02% or less, below Si:1.0 %, Mn:0.2 - 3.0 %, P:0.05% or less, below S:0.005 %, Cr: A presentation which consists of the remainder Fe and inevitable impurities 10 to 14% including nickel:0.2 - 7.0 %, Mo:0.2 - 3.0 %, below aluminum:0.1 %, and N:0.07% or less.
A martensitic phase is made into a main phase and it is not less than 5% of austenite phase at an area rate.

[Claim 2]In addition to said presentation, by mass % further Less than Ti:0.15% and below Nb:0.2 %. Zr: Less than 0.15%, below V:0.2 %, Ta: The high Cr martensitic stainless steel pipe for line pipes containing one sort chosen from 0.15% or less of inside, or two sorts or more according to claim 1.

[Claim 3]The high Cr martensitic stainless steel pipe for line pipes according to claim 1 or 2 which is further characterized by containing below Ca:0.006 % by mass % in addition to said presentation.

[Claim 4]By mass %, C:0.02% or less, below Si:1.0 %, Mn:0.2 - 3.0 %, P:0.05% or less, below S:0.005 %, Cr : 10 to 14%, nickel: 0.2 - 7.0 %, Mo:0.2 - 3.0 %, and below aluminum:0.1 %. After forming a tube using steel stock which has the presentation containing N:0.07% or less and considering it as a steel pipe of a predetermined size, After heating to temperature more than Ac_3 transformation point, cooling subsequently and considering this steel pipe as a hardening organization, 520 A manufacturing method of a high Cr martensitic stainless steel pipe for line pipes excellent in corrosion resistance and weldability considering it as an organization which anneals at temperature more than **, deposits an austenite phase, makes a martensitic phase a main phase, and contains not less than 5% of austenite phase by an area rate.

[Claim 5]In addition to said presentation, by mass % further Less than Ti:0.15% and below Nb:0.2 %. Zr: Less than 0.15%, below V:0.2 %, Ta: A manufacturing method of the high Cr martensitic stainless steel pipe for line pipes containing one sort chosen from 0.15% or less of inside, or two sorts or more according to claim 4.

[Claim 6]A manufacturing method of the high Cr martensitic stainless steel pipe for line pipes according to claim 4 or 5 which is further characterized by containing below Ca:0.006 % by mass % in addition to said presentation.

[0001]
[Field of the Invention]This invention relates to a high Cr martensitic stainless steel pipe suitable as an object for line pipes which conveys petroleum and natural gas, especially relates to an improvement of corrosion resistance and weldability.

[0002]
[Description of the Prior Art]In recent years, development of a depths oil field which was not considered conventionally, a strong corrosive oil field, a gas field, etc., etc. prospers from a viewpoint of the jump in an oil price, and exhaustion of petroleum and natural gas resources expected in the near future. Such an oil field and a gas field are high depth generally, and its place used as the severe corrosive environment which is located in what is called frontier district places, such as marine and very cold land, and contains carbon dioxide CO_2 and chloride-ion Cl^- etc. has increased.

[0003]Under such strong corrosive humid-carbon-dioxide environment, if carbon steel is used as a material of an oil well pipe or a line pipe, it will be corroded remarkably. For this reason, adding an inhibitor in the exploited crude oil and gas as a corrosion prevention means of an oil well pipe or a line pipe has been performed. However, since it becomes insufficient [that addition of an inhibitor serves as a high cost since the inhibitor is expensive, and the addition effect of an inhibitor / an elevated temperature], these days, it replaces with addition of an inhibitor and has a tendency which uses a corrosion-resisting material as a material of an oil well pipe or a line pipe.

[0004]As such a corrosion-resisting material, the martensitic stainless steel which contains Cr 13% has been widely used with the oil well pipe. In order to make the corrosive environment containing a small amount of hydrogen sulfide suit these days, nickel, Mo, etc. are added to the martensitic stainless steel which contains Cr 13%, and the oil well pipe which has improved SSC-proof nature is proposed by JP,60-174859,A, for example. However, the oil well pipe indicated to JP,60-174859,A had the problem that weld cracking occurred, when the consideration to weldability was not made at all but welded without preheating and post heating.

[0005]On the other hand, as a charge of line pipe material, Cr martensitic stainless steel tube is specified to the API standard 12% which reduced C content. However, since this seed steel pipe has low weldability, at the time of welding, need preheating and post heating, the efficiency of welding construction falls, and it becomes a high cost, and also there is a fault that weld zone toughness is low, and there was almost no operating experience. Instead of this seed material, the duplex stainless steel excellent in weldability and corrosion resistance has been used as a charge of line pipe material. However, duplex stainless steel had many amounts of alloy elements, depending on a service space, it will have superfluous performance further, and there was a case where it became expensive economically.

[0006]In a line pipe, in order for hot gas and fluid to flow, it is necessary to keep high the intensity (high temperature strength) of the line pipe at the time of use. In order to make high intensity (high temperature strength) of the line pipe at the time of use, it is usually that the measure of raising the coke strength at ambient temperature of a line pipe, and making high temperature strength high, or increasing the thickness of a line pipe is taken. However, when there is a possibility that weldability may deteriorate if the coke strength at ambient temperature of a line pipe is raised and the thickness of a line pipe is increased, there is a problem of causing the jump of a material cost.

[0007]
[Problem(s) to be Solved by the Invention]Under the corrosive environment which this invention solves advantageously the problem of conventional technology which was described above, and contains carbon dioxide, sufficient general corrosion-proof nature, It aims at proposing a high Cr martensitic stainless steel pipe for line pipes excellent in the corrosion resistance and weldability which show the SSC-proof nature outstanding under the environment which has pitting-proof nature and contains hydrogen sulfide, and have the further outstanding heat affected zone toughness, and a manufacturing method

for the same.

[0008]
[Means for Solving the Problem]This invention persons inquired wholeheartedly about ****** various factors to the toughness of corrosion resistance under corrosive environment containing carbon dioxide of a high Cr martensitic stainless steel pipe and weld cracking, and a heat affected zone, in order to attain the above-mentioned technical problem. [combine / containing making **C and the amount of N into proper content, **nickel, and Mo, considering it as an organization containing austenite beyond **5%, and / as a result / these ** - **] The knowledge of the ability to consider it as a martensitic stainless steel tube possessing corrosion resistance excellent also in the bottom of the first corrosive environment to contain carbon dioxide and weldability was carried out. Becoming the steel pipe which was excellent in SSC-proof nature and heat affected zone toughness especially by this also found out.

[0009]Based on the above-mentioned knowledge, this invention adds examination further and is completed. Namely, a high Cr martensitic stainless steel pipe for line pipes excellent in corrosion resistance and weldability the 1st this invention is characterized by that comprises the following.
By mass %, C:0.02% or less, below Si:1.0 %, Mn:0.2 - 3.0 %, P:0.05% or less, below S:0.005 %, Cr: A presentation as for which nickel:0.2-7.0 %, Mo:0.2 - 3.0 %, and below aluminum:0.1 % consist of the remainder Fe and inevitable impurities 10 to 14% including N:0.07% or less.
An organization which makes a martensitic phase a main phase and contains not less than 5% of austenite phase by an area rate.
In addition to said presentation, in the 1st this invention, by mass % further Less than Ti:0.15%. Nb: Below 0.2 %, Zr : 0.15% or less and below V:0.2 %. Ta: It is preferred to contain one sort chosen from 0.15% or less of inside or two sorts or more, and it is preferred to contain below Ca:0.006 % by mass % further in the 1st this invention in addition to said each presentation.

[0010]The 2nd this invention is mass % and C:0.02% or less and below Si:1.0 %. Mn: 0.2 - 3.0 %, P:0.05% or less, and below S:0.005 %. Cr : 10 to 14%, nickel:0.2 - 7.0 %, Mo:0.2 - 3.0 %, Below aluminum:0.1 % including N:0.07% or less further, Ti: Less than 0.15%, below Nb:0.2 %, Zr : 0.15% or less, Below 0.2 %, Ta : V: One sort chosen from 0.15% or less of inside or two sorts or more are included, Steel stock which has the presentation which consists of the remainder Fe and inevitable impurities preferably is used, After forming a tube and considering it as a steel pipe of a predetermined size, this steel pipe is heated to temperature more than Ac_3 transformation point, Subsequently, after cooling and considering it as a hardening organization, it anneals at temperature more than 520 **, Are it a manufacturing method of a high Cr martensitic stainless steel pipe for line pipes excellent in corrosion resistance and weldability by which it is characterized to consider it as an organization which deposits an austenite phase, makes a martensitic phase a main phase, and contains not less than 5% of austenite phase by an area rate, and in the 2nd this invention. It is preferred to contain below Ca:0.006 % by

mass % further in addition to said presentation.

[0011]
[Embodiment of the Invention]First, the reason for presentation limitation of this invention steel pipe is explained. % only describes mass % hereafter.
Although C:0.02%or less C makes base material intensity increase, it is an element in which the hardness of a heat affected zone is increased, weld cracking sensitivity is improved, and the toughness of a heat affected zone is reduced, and it is desirable to decrease as much as possible in this invention. In order to raise corrosion resistance, such as pitting-proof nature under the corrosive environment containing carbon dioxide, the lower one of C is desirable. In this invention, in order to make welding having no preheating and possible, C may be 0.02% or less. It is 0.01% or less preferably.

[0012]Si: Below 1.0 %Si has the operation which makes intensity increase while acting as a deoxidizer. In order to acquire such an effect, it is desirable that more than 0.1 % contains. Si is a ferritizer, if contained so much, a ferrite will generate and the toughness of a base material and a heat affected zone will deteriorate. For this reason, Si was limited to below 1.0 %. It is 0.1 - 0.5 % preferably.

[0013]Mn: 0.2 - 3.0 %Mn is an element to which intensity is made to increase while acting as a deoxidizer. Mn is an austenite generation element, controls generation of a ferrite, and raises the toughness of a base material and a heat affected zone. Although such an effect is accepted by the content more than 0.2 %, even if contained exceeding 3.0 %, it becomes impossible to expect the effect of an effect being saturated and balancing content, and it becomes disadvantageous economically. For this reason, Mn was limited to the range of 0.2 - 3.0 %. It is 0.5 - 2.0 % preferably.

[0014]Although P:0.05%or less P makes intensity increase, it reduces ductility and toughness and degrades corrosion resistance further. A segregation is carried out to especially a grain boundary, grain boundary intensity is reduced to it, and it has an adverse effect on SSC-proof nature. For this reason, as for P, decreasing as much as possible is desirable. However, extreme reduction causes the jump of a manufacturing cost. Since it was such, in this invention, it was industrial comparatively cheaply feasible, and limited to 0.05% or less of the range which does not degrade toughness and corrosion resistance extremely. It is 0.03% or less preferably.

[0015]S: Below 0.005 % S is an element which forms sulfide system inclusion, such as MnS, and degrades hot-working nature remarkably, and it is desirable to decrease as much as possible also for a productivity drive. However, extreme reduction causes the jump of a manufacturing cost. When reducing S below to 0.005 %, since it could manufacture at the usual process, by this invention, S was limited to below 0.005 %. It is below 0.003 % preferably.

[0016]Cr: 10 to 14%, Cr is an element to which corrosion resistance, such as pitting-proof nature under the corrosive environment which forms a protective coating and contains carbon dioxide, is made to increase while it forms martensitic structure and

raises intensity. In order to acquire such an effect, Cr needs not less than 10% of content. On the other hand, if contained exceeding 14%, the generation tendency of a ferrite will become strong, since content of a lot of [in order to be stabilized and to secure martensitic structure] austenite generation elements is needed, it becomes expensive, and it becomes disadvantageous economically. For this reason, in this invention, Cr was limited to 10 to 14% of range.

[0017]nickel: 0.2 - 7.0 %nickel is an austenite generation element, makes intensity and toughness increase and has the operation which controls the strength reduction by reduction of C and N, and a toughness fall. nickel strengthens a protective coating and makes corrosion resistance, such as pitting-proof nature in the corrosive environment containing carbon dioxide, increase. nickel has the operation of controlling generating of delta-ferrite in an elevated temperature, and improves the hot-working nature of Mo content steel. in order to acquire such an effect, the content more than 0.2 % is needed, but the content exceeding 7.0 % becomes disadvantageous economically in order to carry out abundant addition of the expensive nickel. For this reason, in this invention, nickel was limited to the range of 0.2 % - 7.0 %. It is 0.5 - 5.5 % preferably.

[0018]Mo: 0.2 - 3.0 %Mo is an element to which raise hardenability and intensity is made to increase, and also has the operation which raises SSC-proof nature. In order to acquire such an effect, the content more than 0.2 % is needed, but if contained exceeding 3.0 %, generation of a ferrite will become easy, intensity toughness will fall, and the improved effect of SSC-proof nature will fall further. For this reason, Mo was limited to 0.2 - 3.0 %. It is 0.5 - 2.5 % preferably.

[0019]aluminum: In order that below 0.1 %aluminum might cause the fall of toughness if it is contained exceeding 0.1 % although it acts as a deoxidizer, in this invention, aluminum was limited to below 0.1 %. It is 0.05% or less preferably.
N:0.07%or less N is an element in which the hardness of a heat affected zone is increased, weld cracking sensitivity is improved, and the toughness of a heat affected zone is reduced, and it is desirable to decrease as much as possible in this invention while it dissolves in steel and makes base material intensity increase like C. Since the viewpoint of weld cracking to 0.07% approved, in this invention, N was limited to 0.07% or less. It is 0.03% or less preferably.

[0020]Ti: Less than 0.15%, below Nb:0.2 %, Zr : 0.15% or less, V: Below 0.2 %, Ta : each of one sort chosen from 0.15% or less of inside or two or more sort Ti, Nb, Zr, V, and Ta forms carbon nitride, has the operation which raises the intensity toughness of a base material, and the toughness of a heat affected zone, and can choose and contain it if needed. By replacing Cr carbide by the carbide of these elements, Ti, Nb, Zr, V, and Ta make the amount of effective Cr(s) to pitting-proof nature increase, and raise pitting-proof nature. Ti: 0.15%, Nb:0.2 %, Zr:0.15%, V:0.2 %, Ta : if contained exceeding 0.15%, while weld cracking sensitivity will become high and the danger of weld cracking will increase, In order to degrade the toughness of a base material and a heat affected zone furthermore, it is preferred to make these values into the maximum of each element, respectively. They are Ti:0.01-0.1 %, Nb:0.01-0.1 %, Zr:0.01-0.1 %, V:0.01-0.1 %, and

Ta::0.01-0.1 % more preferably.

[0021]Ca: Below 0.006 %Ca forms the sulfide CaS, controls generation of MnS which is easy to dissolve, and has the operation which raises corrosion resistance. However, a lot of content makes cluster-like inclusion generate, and reduces base material toughness. For this reason, as for Ca, limiting to below 0.006 % is preferred.

[0022]The remainders other than the ingredient which carried out remainder-F(ing) and the inevitable-impurities above are Fe and inevitable impurities. As inevitable impurities, O:0.01% or less is permissible. The organization of this invention steel pipe makes a martensitic phase a main phase, and is taken as the organization which contains not less than 5% of austenite phase by an area rate. The main phase as used in the field of this invention shall mean the phase which occupies not less than 50% by an area rate. While the sludges of Cr, the sludges of Mo, etc. decrease in number and corrosion resistance improves by including austenite not less than 5% in martensite which is a main phase, intensity of a steel pipe can be made low in short time heat treatment. On the other hand, at less than 5%, since there are much Cr and Mo sludge, corrosion resistance falls [an austenite phase]. As there are many austenite phases, they are more preferred from a corrosion-resistant viewpoint, but when it exceeds 35%, there is a problem of becoming difficult to obtain predetermined intensity. For this reason, an austenite phase may be 35% or less preferably not less than 5%.

[0023]The organization of this invention steel pipe is delta in addition to the phase described above although it was an organization which makes martensite a main phase as described above, contains austenite, and contains the sludge below 3 more% (area rate). - Even if it contains a ferrite below 3% (area rate), it is satisfactory in any way. Below, the manufacturing method of the high Cr martensitic stainless steel pipe for line pipes of this invention is explained.

[0024]First, it is preferred to ingot the molten steel of the above-mentioned presentation by the usually publicly known ingot methods, such as a converter and an electric furnace, and to use it as steel tube stock, such as a billet, by a continuous casting process or steel ingot-slabbing. The usual tubulation process [these steel tube stock], i.e., heat, and the Mannesmann boring machine punches, hot-roll using skew rolling method mills, such as a plug mill method and a mandrel method, and make it into the seamless steel tubes of a prescribed dimension, is preferred. It cannot be overemphasized that welded steel pipes, such as not the thing limited to seamless steel tubes but an electroseamed steel pipe, a UOE steel pipe, and a spiral weld pipe, may be used in this invention.

[0025]As for an electroseamed steel pipe, it is preferred to, make steel tube stock of the above-mentioned presentation into a steel strip with hot-rolling for example, and to consider it as the electroseamed steel pipe of a prescribed dimension according to the usual tubulation process, i.e., a shaping-welding-correction process. Also as for a UOE steel pipe and a spiral weld pipe, it is [especially the tubulation process] preferred for it not to be limited, to form a tube according to the usual UOE steel pipe manufacturing process and a spiral weld pipe manufacturing process, and to consider it as the steel pipe

of a predetermined size.

[0026]It is heated by the temperature more than Ac_3 transformation point, and, subsequently is cooled with the cooling rate more than air cooling, and the steel pipe of a prescribed dimension which is manufactured by the above-mentioned usual tubulation process, and has the above-mentioned presentation is considered as a hardening organization. The cooking temperature of cooking temperature of a steel pipe is too low at less than Ac_3 transformation point, a perfect austenite texture is not obtained, and sufficient hardening organization is not obtained. Here, sufficient hardening organization means the organization which has not less than 95% of hardening martensite by an area rate. On the other hand, since an austenite grain will become big and rough and toughness will deteriorate if it exceeds 1050 **, it is preferred to make 1050 ** into the maximum of cooking temperature.

[0027]It cools to a room temperature with the hardening cooling rate more than air cooling after heating a steel pipe. Each of air cooling, mist cooling, water cooling, etc. is preferred for cooling. A steel pipe is annealed at the temperature more than 520 ** after hardening. As for tempering conditions (temperature, time), it is preferred to consider it as the conditions which an austenite phase generates not less than 5%. In order for tempering temperature to make an austenite phase generate not less than 5% by less than 520 **, prolonged annealing is needed and productivity is checked. For this reason, tempering temperature is the temperature more than 520 **, and it is preferred to consider it as the temperature below Ac_1 transformation point more preferably. Still more desirable tempering temperature is 600 - 650 **.

[0028]
[Example]Steel of the presentation shown in Table 1 was ingoted with the converter, and after performing and refining vacuum degassing treatment, it was considered as steel tube stock (billet) by the continuous casting process. Such steel tube stock was heated, the tube was formed with the mill of the Mannesmann mandrel method, and it was considered as seamless steel tubes with an outer diameter 273 mmx thickness of 12.7 mm. Subsequently, the conditions shown in Table 2 were heat-treated to these steel pipes (hardening-annealing), and it was made them with the steel pipe of X80 grade.

[0029]From these steel pipes, the specimen was extracted, organization investigation, the tensile test, the impact test, and the corrosion test were carried out, and intensity, toughness, and corrosion resistance were evaluated. The specimen was extracted in the state of a hardening as and the hardening organization was investigated.
(1) About the section vertical to the longitudinal direction of organization investigation each steel pipe, the organization was picturized with the optical microscope or the scanning electron microscope, and the each phase's existence area rate was measured using the image analyzing device. The amount of austenite phases (gamma) under organization was computed using the X-ray diffraction method from the ratio of the diffraction intensity from (220) of gamma, and the diffraction intensity from (211) of alpha.
(2) The round bar specimen of 6 mmphi was extracted from the longitudinal direction of

tensile test each steel pipe, the tensile test was carried out, and yield strength YS, tensile strength TS, and the elongation El were measured.
(3) The JIS No. 4 specimen was extracted from the longitudinal direction of impact test each steel pipe, the impact test was carried out at test temperature:-40 **, and Charpy absorbed energy vE_{-40} was measured.
(4) The specimen (size: 3.0x25x50 mm) extracted from corrosion test ** carbon dioxide corrosion test each steel pipe was pulled up after the carbon dioxide of 3.0MPa was immersed for seven days with autoclave into the saturated 25 mass % NaCl aqueous solution (solution temperature: 100 **). About the specimen pulled up, after removing a corrosion product, the existence of pitting was investigated by viewing. Then, the specimen weight after a corrosion test was measured, and it converted into the board thickness decrement, and asked for the corrosion rate (mm/y).

[0030]That in which O and pitting did not generate what pitting generated from these results evaluated pitting-proof nature as x. Making corrosion rate:0.127 mm/y into full limits, that what shows the corrosion rate more than these full limits indicates the corrosion rate of x and less than full limits to be evaluated carbon dioxide-proof corrosiveness as O.
** Using the specimen (size: 6.4mm phi) extracted from SSC examination each steel pipe, according to regulation of NACE-TM 0177 method A, the constant stress examination was carried out and SSC-proof nature was evaluated. Test liquid is 5 mass %NaCl+0.5. It was considered as mass %CH_3COOH solution, CH_3COONa was added, and the pH to 3.5 was adjusted. It examined blowing the mixed gas of S+99% of 1%H_2CO_2 into test liquid. Load stress set to YS 90%, and test time was set to 720 h. YS used the yield stress (654MPa) of the standard minimum of X80.

[0031]Two steel pipes (length: 0.5 m) of an identical kind were prepared, ends (V edge preparation) were compared, circumferential weld was carried out using the GMAW welding process, and the steel pipe joint was produced. The existence of generating of weld cracking was investigated about the produced steel pipe joint part. Making the welding condition of circumferential weld into the GMAW welding process of heat input:19.5 kJ/cm (voltage: 14.5V, current:157 A, speed-of-travel:7.0 cm/min), preheating and post heating presupposed that it is nothing.

[0032]Investigation of weld cracking was based on section observation of welding. Those of weld cracking without generating were made into O, those with a crack generation were made into x, and weld-cracking nature was evaluated. The test piece for Charpy impact test (JIS No. 4 specimen) was extracted from the heat affected zone (HAZ) (from a bond to 1 mm) of the steel pipe joint part, and Charpy absorbed energy vE_{-40} in test temperature:-40 ** was calculated.

[0033]These results are shown in Table 2.

[0034]
[Table 1]

[0035]
[Table 2]

鋼No	化学成分（質量%）											
	C	Si	Mn	P	S	Cr	Ni	Mo	Al	N	Ti、Nb、Zr、Ta、V	Ca
A	0.012	0.31	1.35	0.02	0.001	12.6	5.12	1.86	0.02	0.014	－	－
B	0.011	0.51	1.08	0.02	0.001	12.4	4.86	1.67	0.02	0.021	Nb:0.024, V:0.033	－
C	0.009	0.31	1.28	0.02	0.001	11.8	3.19	1.99	0.02	0.014	Ti:0.047	－
D	0.008	0.22	1.43	0.01	0.001	12.1	4.31	1.98	0.02	0.008	Zr:0.016, V:0.016, Ta:0.011	－
E	0.010	0.21	1.04	0.02	0.002	12.2	4.59	1.86	0.01	0.012	－	－
F	0.011	0.29	1.39	0.01	0.001	11.9	5.33	2.35	0.02	0.018	－	0.031
G	0.010	0.25	1.55	0.01	0.001	12.8	4.55	1.78	0.02	0.008	V:0.027	0.002
H	0.012	0.32	1.31	0.02	0.001	11.8	3.74	0.01	0.02	0.019	－	－
I	0.011	0.33	1.38	0.02	0.002	9.8	4.29	2.06	0.02	0.023	Nb:0.011, V:0.047	－
J	0.014	0.28	1.26	0.01	0.001	12.6	2.51	1.39	0.02	0.009	Ti:0.025	－
K	0.031	0.31	1.28	0.02	0.002	12.1	3.92	1.59	0.02	0.012	－	－
L	0.012	0.29	1.06	0.01	0.002	12.0	0.14	1.41	0.02	0.009	－	－
M	0.009	0.30	1.19	0.01	0.001	12.3	4.35	1.66	0.02	0.075	－	－
N	0.014	0.24	1.24	0.01	0.002	11.6	4.66	1.73	0.02	0.016	Ti:0.039	－

鋼管No	鋼No	熱処理条件		鋼管組織		鋼管特性							備考
		焼入れ	焼戻し	種類		溶接部靱性		溶接割れ性	耐食性				
		温度 ℃	温度 ℃	M* 面積%	γ* 面積%	母材 vE_{-40} J	HAZ vE_{-40} J	割れの有無	腐食速度 mm/y	腐食速度 評価	孔食有無	耐SSC性 割れ有無	
1	A	930	630	75.0	24.3	305	219	無	0.031	○	○	○	本発明例
2		920	630	73.5	25.8	331	263	無	0.030	○	○	○	本発明例
3			610	84.9	14.3	184	216	無	0.034	○	○	○	本発明例
4		910	510	95.9	3.2	166	197	無	0.035	○	○	×	比較例
5			500	97.4	1.7	126	134	無	0.039	○	○	×	比較例
6	B	970	620	81.3	17.9	175	250	無	0.035	○	○	○	本発明例
7		930	630	76.2	23.1	216	269	無	0.034	○	○	○	本発明例
8		910	610	85.4	13.8	198	226	無	0.037	○	○	○	本発明例
9			510	95.2	3.9	145	185	無	0.034	○	○	×	比較例
10	C	910	610	92.7	6.5	189	193	無	0.077	○	○	○	本発明例
11	D	910	610	86.8	12.5	218	258	無	0.042	○	○	○	本発明例
12	E	910	600	89.5	9.7	187	204	無	0.037	○	○	○	本発明例
13	F	910	610	82.9	16.4	202	238	無	0.044	○	○	○	本発明例
14	G	910	610	84.6	14.7	206	249	無	0.032	○	○	○	本発明例
15	H	910	600	91.7	7.5	182	205	無	0.091	○	×	×	比較例
16	I	910	610	85.5	13.6	129	156	無	0.294	×	×	×	比較例
17	J	910	610	96.0	3.1	162	164	無	0.057	○	○	×	比較例
18	K	910	610	92.0	6.6	38	29	有	0.085	○	×	×	比較例
19	L	930	610	98.3	0.5	26	28	無	0.147	×	×	×	比較例
20		910	630	98.3	0.6	31	30	無	0.134	×	×	×	比較例
21	M	910	610	86.3	12.5	29	4	有	0.074	○	○	×	比較例
22	N	910	610	86.1	13.1	179	171	無	0.055	○	○	○	本発明例

*)M:マルテンサイト, F:フェライト, B:ベイナイト, γ:オーステナイト

[0036]Each example of this invention can carry out circumferential weld, without having the outstanding intensity and toughness and performing preheating and stress relief heat treatment further, Weld-cracking-proof nature and heat affected zone toughness are

excellent, and also it turns out that it excels in pitting-proof nature and general corrosion-proof nature also under the corrosive environment containing carbon dioxide, and has become the steel pipe which was excellent in SSC-proof nature under the corrosive environment which contains hydrogen sulfide further. On the other hand, any one or more of the characteristics which the comparative example which separates from the range of this invention described above have deteriorated.

[0037]

[Effect of the Invention]According to this invention, also in the corrosive environment containing carbon dioxide or the corrosive environment containing hydrogen sulfide, it excels in corrosion resistance, And preheating and stress relief heat treatment are not needed, but the high Cr martensitic stainless steel pipe for line pipes in which circumferential weld is possible can manufacture cheaply and easily, and does a marked effect so industrially. According to this invention, the pipeline who conveys petroleum and natural gas can manufacture cheaply.